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(54) Ensuring correct assembly of screwed pipejoints

(57) During screwing up the screwing torque is measured continuously, the value of the second differential of the screwing torque is determined uninterruptedly, and the maximum of this second differential is checked for comparison with a predetermined value.

The device includes in combination: a means of producing an electric voltage dependent on the value of the tightening torque applied at every instant during the screwing up of the joint, an electronic device for carrying out the calculation of the second differential of the curve of electric voltage so measured, and a device enabling the value of this second differential to be compared with a reference value for giving a signal when the maximum of the second differential exceeds or does not exceed the reference value.

Fig. 5

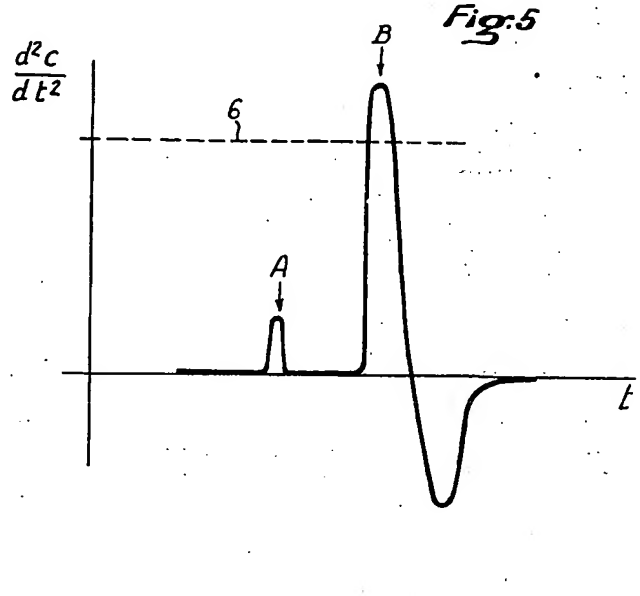

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Fig:1

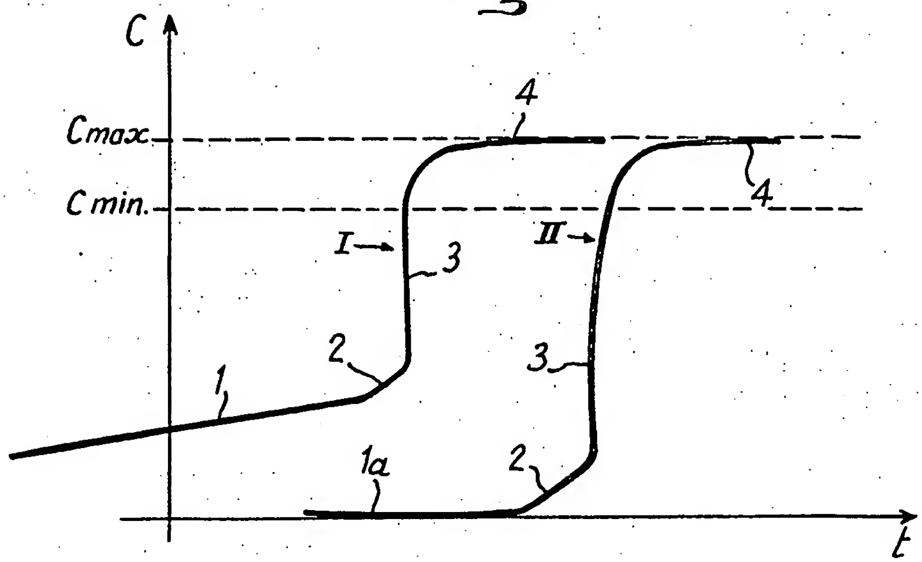


Fig:2

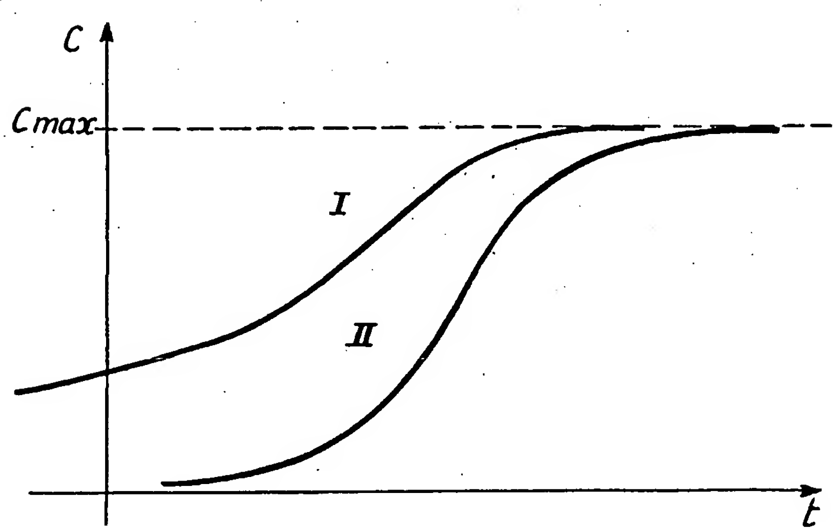


Fig:3

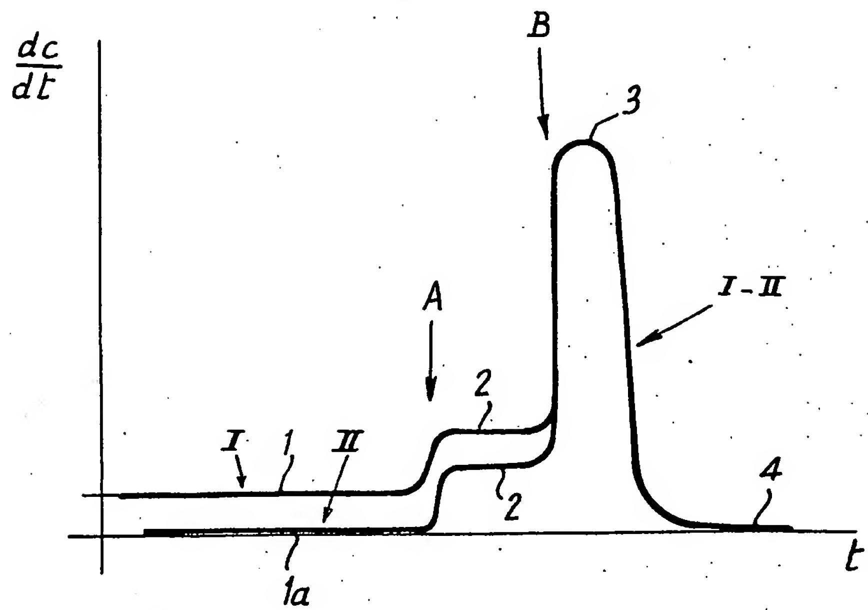


Fig:4

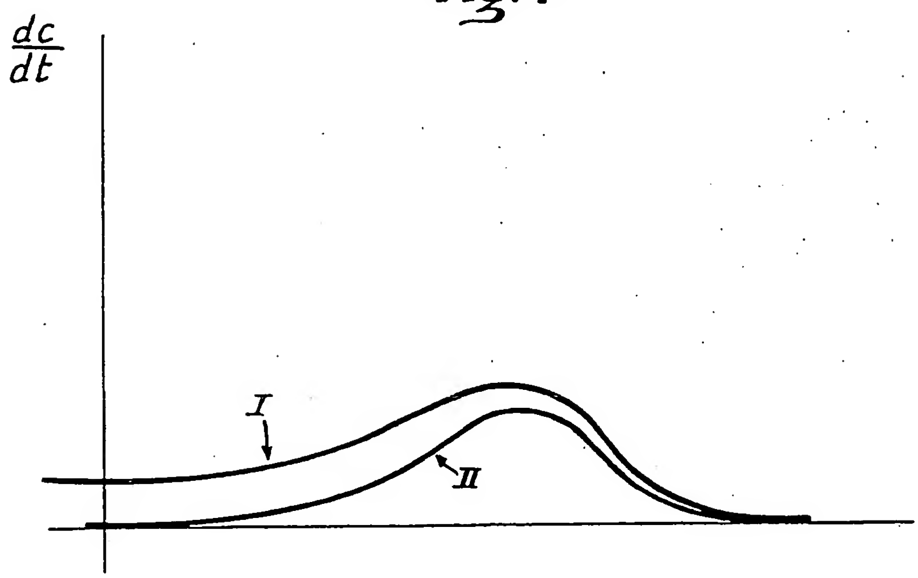


Fig:5

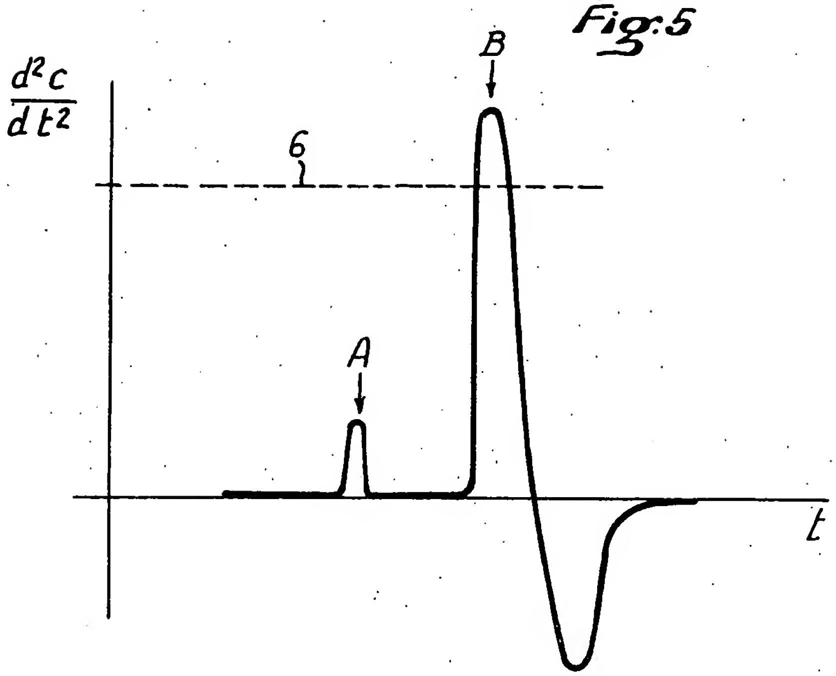


Fig:6

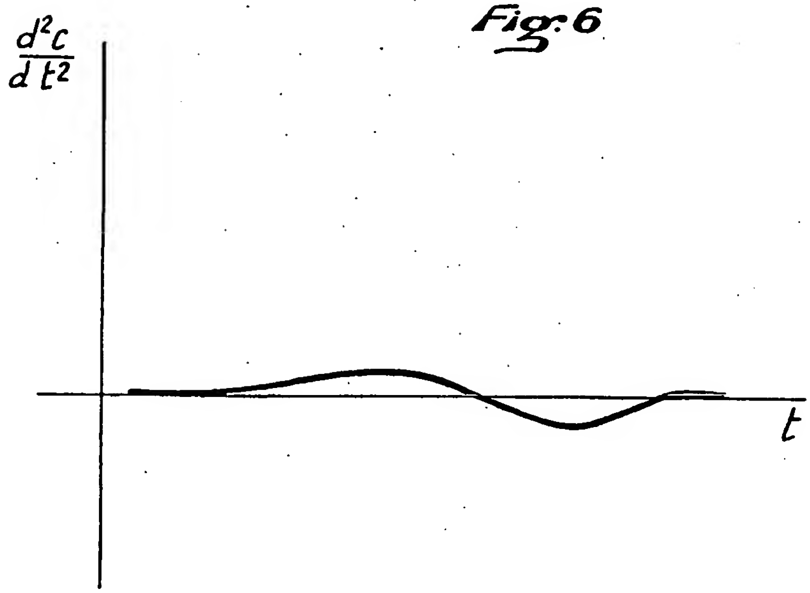


Fig. 7

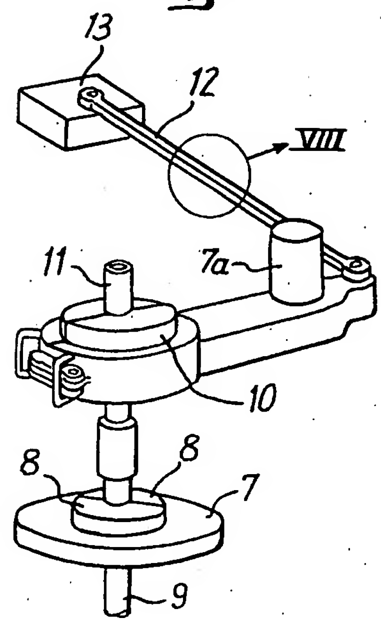


Fig. 8

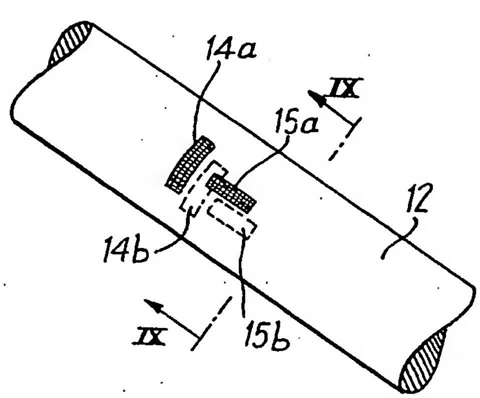
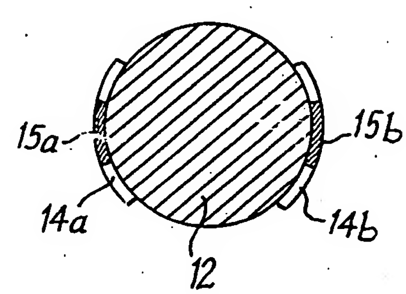


Fig. 9



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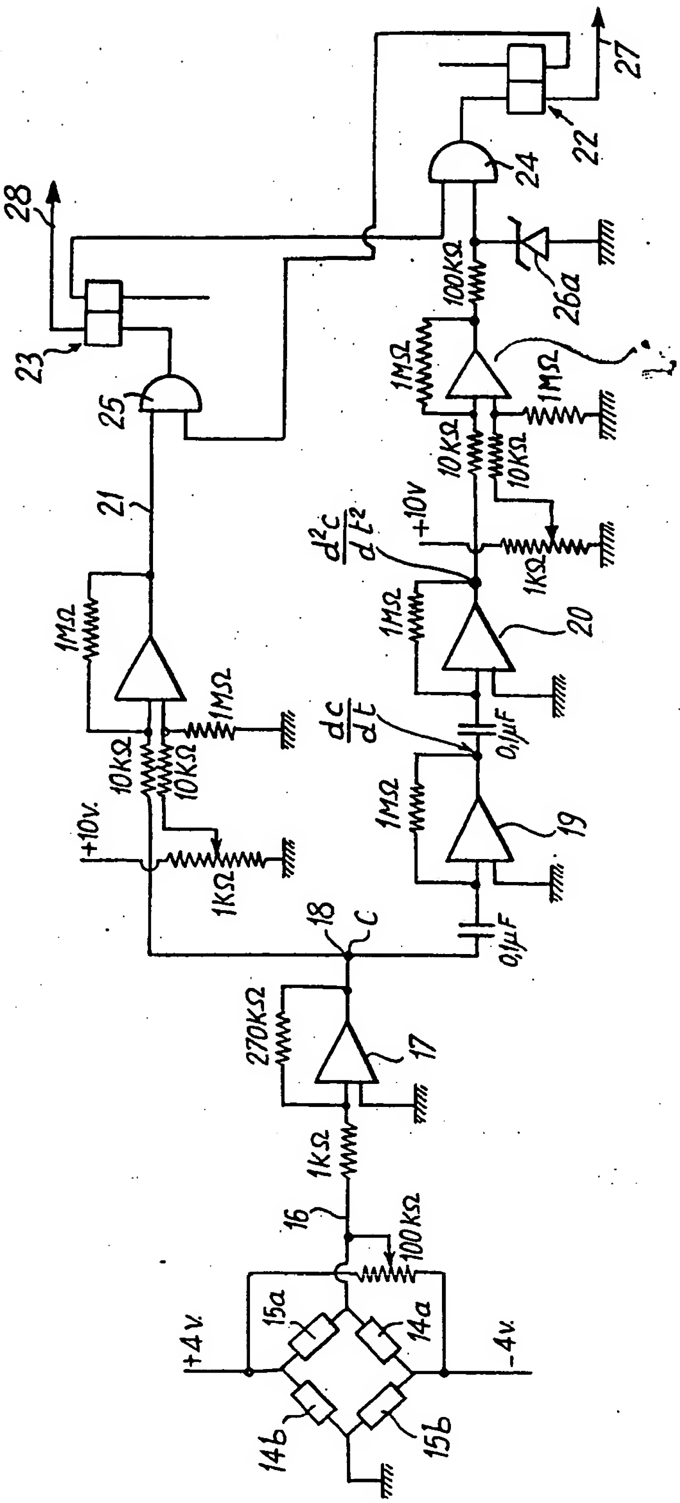

Fig:10

SPECIFICATION

Method and device for ensuring the correct screwing up of a pipejoint having a stop for restricting screwing up

The present invention relates to a new method and a device for putting it into effect, which enable it to be checked that the screwing up of a threaded pipejoint having at least one stop for restricting screwing up, is carried out correctly.

Threaded pipejoints are known, which are employed in particular in the oil industry and especially in oil wells, which have taper or cylindrical threads as well as at least one stop integral with one of the members in order to restrict the screwing up at the time of the assembly of the two members.

The idea is already equally well known of effecting the assembly of such joints by applying a screwing torque which lies within a zone of predetermined values, the screwing torque being applied by a device which enables it to be measured.

This way of doing it does not entirely give satisfaction because it may occur that by reason, for example, of the presence of a foreign body such as a chip of metal in the lubricant on the threads, or in consequence of a seizure at the level of the threads, the predetermined maximum torque is reached as a result of abnormally high resistance to the screwing up and without the surfaces of the stop for restriction of the screwing up, coming correctly into contact with one another. The result is defective tightening of the joint because under this assumption the sealing surfaces are in general not in contact or are in contact only in an unsatisfactory way.

The object of the present invention is a new method and a new device which enable this disadvantage to be eliminated simply and at low cost.

The object of the present invention is a method of ensuring correct assembly of screwed pipejoints having at least one stop for restricting screwing up, characterized by the fact that during screwing up the screwing torque is measured continuously as a function of the time, that the value of the second differential of the screwing torque is determined ;uninterruptedly with respect to time, and that the maximum of this second differential is checked to exceed a predetermined value.

In particular highly improved mode of putting into effect the method in accordance with the invention, it is likewise checked during screwing up that the screwing torque does not exceed the prescribed minimum nominal value before the second differential of the torque exceeds the value predetermined for this differential. It is thus ensured in addition that when the nominal screwing torque has been reached, the maximum of the second differential of the torque which has been found, was not due to another aberrant phenomenon which might occur after the normal process of screwing up the joint.

This method may be put into effect in accordance with the invention by measuring the screwing torque exerted between the two pipe members by means, for example, of a pick-up consisting of strain gauges, which enables the value of the screwing torque exerted between the two pipe members to be converted instantaneously into the form of an electric voltage.

An electronic device of known type enables the second differential with respect to time to be calculated in real time from the voltage curve thus obtained, and it is sufficient to compare the value of this second differential with a threshold value in order to determine whether the maximum of this curve does or does not exceed the predetermined threshold.

In order to ensure that in accordance with the particular mode described above, of putting the method into effect, the screwing torque reaches its minimum nominal value after the maximum of its second differential, one may, for example, feed a flipflop system by means of two AND gates which receive voltages which correspond with the excess of the torque and of its second differential with respect to their threshold values.

In a variant upon the invention one measures permanently the screwing torque and the second differential of the latter, not with respect to time but with respect to the angular displacement of one of the members with respect to the other during screwing up.

This rotation or angular displacement may easily be measured thanks to devices of known types which enable a given number of electrical pulses to be generated, which is directly proportional to the rotation of one pipe member with respect to the other.

The differential of the torque with respect to the angular displacement is then equal to the difference between the torques measured at the instants of two consecutive pulses and the second differential is equal to the difference between the first differentials from two consecutive pulse intervals. These various calculations may easily be achieved with a microprocessor or mini-micro computer of known type.

It results from experiments which have been made by the Applicant Company, that this method enables it to be determined in a perfectly reliable manner whether a pipejoint having a stop for restricting screwing up has been correctly screwed up, that is to say, whether the tightening torque which has been exerted during screwing up is due to the normal operation of the joint or whether it is due to an accident in operation such as a seizure or the presence of a foreign body at the level of the threads.

In fact in general the torque necessary for the tightening of a pipejoint of this type increases progressively rather slowly when the thread is taper (or remains substantially constant when the thread is cylindrical) and then increases during a short period with a rather low proportionality at the time of the approach of the sealing surfaces, after which the torque increases abruptly when the surfaces for restricting screwing up, come into contact. This is the case at least when the tightening of the joint is carried out under normal conditions.

The result is that when the surfaces for restricting screwing up come into contact, an abrupt variation occurs in the slops, that is to say, in the first differential of the curve of the torque, which shows

as a high value of the second differential of the torque.

On the contrary, when the tightening of the joint is carried out in an abnormal manner, the screwing torque increases in a substantially progressive manner which does not bring about any abrupt variation in the differential of the torque, which is shown by values of the second differential which are always relatively low.

Under these conditions it may be seen that by measuring the maximum value of the second differential of the torque with respect to time, or with respect to the angular displacement of one member with respect to the other, it may be determined in a simple manner whether the joint has been correctly screwed up.

The object of the present invention is likewise a new device for putting into effect the method defined above, this device being characterized by the fact that it includes in combination: a means of converting into electric voltage the value of the tightening torque applied at every instant during the screwing up of the joint, an electronic device for carrying out the calculation of the second differential of the curve of electric voltage so measured, and a device enabling the value of this second differential to be compared with a reference value for giving a signal when the maximum of the value of the second differential does not exceed the reference value, which is the sign of defective tightening of the joint.

In a preferred embodiment the screwing torque is compensated by a connecting rod connected to a fixed point, the axial forces exerted upon the connecting rod enabling the value of the screwing torque to be determined.

The device enabling the screwing torque to be converted into electric voltage may be of known type and may, for example, call upon strain gauges which in the particular embodiment described above are located on the connecting rod. Similarly devices are already known which by means of an amplifier, a capacitor and a resistor enable the differential of a voltage to be obtained with respect to time. The employment of two such devices in succession enables the second differential to be obtained.

With the aim of letting the invention be better understood, there will now be described by way of illustration and without any restrictive character, an embodiment taken as an example and represented in the drawing attached.

In this drawing.-

Figure 1 represents diagrammatically the normal development of the screwing torque as a function of time, firstly for a joint having taper threads and secondly for a joint having cylindrical threads;

Figure 2 corresponds with Figure 1 in the case in which the screwing up is carried out in an abnormal manner;

Figures 3 and *4* represent the curves of the first differentials with respect to time, of the torques represented respectively in Figures 1 and 2;

Figures 5 and *6* represent the second differentials with respect to time, of the screwing torques represented in Figures 1 and 2;

Figure 7 represents diagrammatically a device enabling the putting into effect of the method in accordance with the invention;

Figure 8 is a view on a larger scale of the portion VII of Figure 7;

Figure 9 is a section along IX - IX in Figure 8;

Figure 10 is a diagram of an electronic device which enables the method in accordance with the invention to be put into effect.

In Figure 1 are shown the curves I and II which represent the development of the value of the tightening torque of a joint as a function of time.

The curve I corresponds with the case of a joint having a taper thread giving a force fit, which includes sealing surfaces which come into contact before the surfaces come into contact on the stops for restricting screwing up.

Thus the curve I exhibits a slightly rising portion 1 which corresponds with the increase in the torque due to the engagement of the threads on the male member in those on the female member.

The portion 2 of the curve corresponds with the increase in the contact pressure of the sealing surfaces, whereas the portion 3 of the curve which rises very rapidly corresponds with the phase in which the surfaces for restricting screwing up, come to a stop against one another.

The portion 4 corresponds with the maximum value *Cmax* of the screwing torque which is effectively applied.

In the curve II which corresponds with a joint having a cylindrical thread the same portions of curves 2, 3 and 4 are found again, which correspond with the tightening in succession of the sealing surfaces and of the surfaces for restricting screwing up. However, taking into account the fact that the cylindrical threads do not exert any force fit, the portion 1*a* of the curve II remains flat whereas the portion 1 of the curve I which corresponds with taper threads rises slightly.

In Figure 2 the curves are shown which correspond with the tightening of the joints as Figure 1 but under the assumption that the screwing up is carried out under abnormal conditions by reason either of seizure of the threads or else, for example, of the presence of a foreign body in the threads.

Under these conditions it will be observed that the curve of the torque with respect to time appears in the general shape of an elongated S which is due to the fact that the seizure or the foreign body causes a relatively steady increase in the tightening torque so that the different portions 1, 2, 3 or 1*a*, 2 and 3 have practically disappeared.

In Figure 3 the curve is shown of the differential of the torque with respect to time, corresponding with each of the curves I and II in Figure 1.

It will be observed that the portion 1 of the curve I in Figure 1 corresponds with the level stretch 1 in Figure 3 (curve I), that the portion 2 of the curve I in Figure 1 corresponds with the level stretch 2 in Figure 3, that the portion 3 of the curve I in Figure 1 corresponds with the maximum 3 in Figure 3 and that the level stretch 4 of the maximum torque from curve I in Figure 1 corresponds with the portion 4 in Figure 3.

The curve II in Figure 3 has a trend similar to that

of the curve I, the only difference consisting in the fact that the level stretch 1*a* has zero value whereas the level stretch 2 of the curve II is in this embodiment at a lower level than that of the curve I.

It may clearly be seen that the portions 1 or 1*a* in Figure 1 which are connected at an angle to the portions 2 which in turn are connected at an angle to the portions 3 give successive level stretches in the curves of the differentials in Figure 3.

On the contrary, by reason of the absence of abrupt variations in the torque in the curves from Figure 2, it may be observed in Figure 4 that the first differentials of the torque with respect to time vary continuously and with the general shape of a curve having a very much rounded maximum when an accident occurs during screwing up of the joint.

In Figure 5 is shown the curve of the second differential with respect to time, of the curves representing the screwing torques in Figure 1.

It may be observed in this Figure 5 that the zones A and B of rapid variation in the value of the first differential in Figure 3, correspond with peaks in the curve of the second differential in Figure 5 in the case of screwing up correctly.

It may be observed on the contrary that the second differential of the screwing torque with respect to time, which is represented in Figure 6 in the case of abnormal tightening of the joint due, for example, to seizure of the threads or to the presence of a foreign body in the threads, appears in a very flattened wavy shape.

Under these conditions it may be seen that by measuring the value of the peak B of the curve of the second differential in Figure 5 and by comparing this value with a reference value indicated, for example, by the dotted line 6, it is possible to determine with accuracy whether the screwing up of the joint has been carried out under normal conditions or not.

In Figure 7 which represents diagrammatically a device for putting the invention into effect, the conventional devices for the tightening of the joints on a wellhead are found, which includes a revolving plate 7 equipped with jaws 8 capable of fixing the lower portion 9 of the pipe and a device having revolving jaws 10 which may be brought to grip the upper portion of the pipe 11 and drive it in rotation by means of a motor 7a through a known device which is not shown.

For putting into effect the method in accordance with the invention, and in a quite conventional manner, the revolving plate 7 is fixed in rotation and the driving of the portion 11 of the pipe in rotation by the motor 7*a* and by the revolving jaws 10, tends to make the assembly supporting the jaws 10 and the motor 7*a* revolve about the axis of the pipe with a torque equal to the screwing torque. In order to avoid rotation of the whole of the device it is connected by a connecting rod 12 to a fixed portion 13.

In accordance with a particular embodiment of the device in accordance with the invention, the measurement of the torque is carried out by means of strain gauges located upon the connecting rod 12 diagrammatically shown in Figure 7.

It is shown on a larger scale in Figures 8 and 9 how four strain gauges 14*a*, 14*b* and 15*a*, 15*b* are arranged by pairs circumferentially and longitudinally on the connecting rod 12.

It is known that by measuring the variation of the electrical resistances of these four strain gauges it is possible to determine the longitudinal stresses which are applied to the connecting rod 12 and which are directly proportional to the screwing torque exerted by the revolving jaws 10 on the upper portion 11 of the joint, the lower portion 9 of which is fixed.

Figure 10 represents an embodiment of an electronic device which enables it to be determined from the indications which are supplied to it by these strain gauges, whether the screwing up of the joint has been carried out under normal conditions or not.

In Figure 10 the strain gauges 14*a*, 14*b* and 15*a*, 15*b* are found again, which are mounted conventionally. A variable resistor of 100 kilo-ohms enables the voltage at the point 16 to be adjusted to zero when the torque is zero. The supply voltage and the dimensions of the connecting rod 12 are such that in the embodiment described the voltage at the point 16 is about 10 millivolts for a torque of 1000 metre-kilos. An amplifier 17 enables a volteage to be obtained at the point 18 of about 2 volts for a torque of 1000 metre-kilos. This voltage is proportional to the torque *C*.

A device 19 consisting of an amplifier associated with a capacitor enables the differential dC/dt of the torque to be obtained, and then a second device 20 consisting of an amplifier associated with a capacitor enables the second differential of the torque d^2C/dt^2 to be obtained.

A device 26 including an amplifier and a variable resistor enables an adjustable threshold to be determined, corresponding with the value 6 in Figure 5, and a voltage to be applied to the AND gate 24, corresponding with the excess of the second differential with respect to the adjustable threshold value, this voltage being in turn subjected to an amplitude limiter 26*a*.

In parallel, a conventional device including in particular an amplifier and a variable resistor of 1 kilo-ohm, enables a voltage to be obtained at 21 which is equal to the excess of the instantaneous value of the screwing torque with respect to the value of the minimum nominal torque to which the joint must be tightened, the variable resistor enabling this latter value to be adjusted.

By means of a conventional device including two flipflops 22 and 23 which are fed through two AND gates 24 and 25, the gate 24 receives the voltage corresponding with the excess of the second differential with respect to the reference threshold, whereas the gate 25 receives the voltage which corresponds with the excess of the tightening torque with respect to the minimum normal torque.

This known device consisting of flipflops enables a signal to be obtained at 27 at the end of the screwing up, solely when the second differential reaches its threshold value (6, Figure 5) before the minimum nominal torque (*Cmin*, Figure 1) has been reached. In the opposite case (minimum nominal torque before the peak of the second differential) a signal is

emitted at 28.

Thus at 27 a signal is obtained enabling it to be displayed that the screwing up has been carried out correctly, and at 28 a signal enabling it to be displayed that the screwing up has been carried out in an abnormal manner.

It may be seen that the device in accordance with the invention, of which a particular embodiment has just been described, enables a method to be obtained with simple means, for determining whether the screwing up of a joint of the type described above has been carried out under satisfactory conditions.

It goes without saying that the embodiments which have been described above are given purely by way of indication, and that they might receive any desirable modifications without thereby departing from the scope of the invention.

There exist in fact numerous means which enable a torque to be measured instantaneously and the second differential of it to be calculated. It is clear that the employment of other devices or equivalent means would not depart from the scope of the invention. In particular it is clear that in accordance with the invention it is not indispensable to check that the tightening torque exceeds its minimum nominal value after the peak in implementation described above.

Similarly the invention is in no way restricted to a particular type of joint and it is sufficient in order to be able to put into effect the method which has been described, that the joint includes stops for restricting screwing up, which during normal screwing up cause an abrupt increase in the screwing torque.

CLAIMS

1. A method of ensuring correct assembly of screwed pipe-joints having at least one stop for restricting screwing up, in which during screwing up the screwing torque is measured continuously, that the value of the second differential of the screwing torque is determined uninterruptedly, and that the maximum of this second differential is checked to exceed a predetermined value.

2. A method as in claim 1, in which the second differential of the torque is determined with respect to time.

3. A method as in claim 2, in which the second differential of the torque is determined with respect to the relative angular displacement of the two pipe members.

4. A method as in any one of the preceding claims, in which the screwing torque exerted between the two pipe members is measured by means of a pick-up consisting of strain gauges.

5. A method as in any one of the preceding claims, in which it is checked that the screwing torque exceeds its minimum nominal tightening value.

6. A method as in claim 5, in which it is checked that the screwing torque is exceeding its minimum nominal tightening value after its second differential has exceeded its threshold value.

7. A device for putting into effect the method as in any one of the preceding claims, which includes in combination a means of converting into electric voltage the value of the tightening torque applied at every instant during the screwing up of the joint, an electronic device for carrying out the calculation of the second differential of the curve of electric voltage so measured, and a device enabling the value of this second differential to be compared with a reference value for giving a signal when the maximum of the second differential exceeds or does not exceed the reference value.

8. A device as in claim 7, in which the screwing torque is compensated by a connecting-rod fastened to a fixed point and equipped with strain gauges for enabling measurement of the axial stresses which are exerted upon it and determination of the value of the screwing torque.

9. A device as in either of the claims 7 and 8 in which the second differential with respect to time, of the voltage corresponding with the torque is obtained by means of two successive known devices which enable the differential of a voltage to be obtained by means of an amplifier, a capacitor and a resistor.

10. A device as in any one of claims 7 to 9, which includes devices having adjustable threshold values which enable a flipflop device to be actuated by way of AND gates when the second differential and the torque exceed in succession their respective threshold values, in order to give a signal that the screwing up has been carried out satisfactorily.

11. A method of ensuring correct assembly of screw pipe joints substantially as described herein with reference to and as shown in the accompanying drawings.

12. A device for carrying out the method substantially as described herein with reference to and as shown in the accompanying drawings.

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